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NATIONAL FIRE-DANGER RATING SYSTEM FINE-FUEL MOISTURE CONTENT TABLES--AN ALASKAN ADAPTATION

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ABSTRACT

Fine-fuel moisture content tables, using dry bulb and dewpoint temperatures as entry data, have been developed for use with the National Fire-Danger Rating System in Alaska. Comparisons have been made which illustrate differences resulting from danger-rating calculations based on these new fine-fuel moisture tables versus the standard NFDRS tables. New fine-fuel moisture content tables for the cured, transition, and green herbaceous stages of fuel are provided.

INTRODUCTION

This note discusses tables of fine-fuel moisture content which were developed for use with the National Fire-Danger Rating System (NFDRS) in Alaska. These new tables, which are actually local supplements to the NFDRS, use dry bulb and dewpoint temperatures[1/] as the basic data for entry into the tables. Comparisons have been made illustrating differences resulting from danger-rating calculations based on the "new" fine-fuel moisture tables versus the standard NFDRS fine-fuel moisture tables.[2/]

1/ Fahrenheit is used throughout this report.

2/ U.S. Forest Service. National Fire-Danger Rating System handbook, 5100-26 (rev. 2/64).

In review, the initial stage of development of the NFDRS was the spread phase. A basic spread index provides ratings of the relative rate of spread for either fine or intermediate fuels. Figure 1 shows diagrammatically the spread phase and its components. As can clearly be seen, fine-fuel moisture is really the key component. This element was normally obtained by use of either dry bulb temperature and relative humidity or dry bulb temperature and wet bulb depression.

The tables, as presented in this paper, have been adopted by the Bureau of Land Management for use throughout the interior of Alaska. These same tables have also been used in development of danger-rating information from historical weather records on which only dry bulb temperatures and dewpoint temperatures were available. Computer programs have also been adapted to utilize the fuel moisture tables outlined.

PROBLEM

Two closely related local problems prompted the development of an additional set of tables to supplement those already available. In one case, a historical record for Alaska on the broadest data base possible was needed for research and development purposes. The second problem involved the day-to-day requirements of protection agencies using the NFDRS in Alaska. Many of the weather records for Alaska have only dry bulb and dewpoint temperatures on them. Over 50 percent of the fire-danger station network observations in Alaska are obtained from the Federal Aviation Administration and Weather Bureau teletype network stations which provide only dry bulb and dewpoint temperatures. Essentially then, data for Alaska--both of a historical nature and for daily operational use--was not available in a readily usable form. Therefore, if fine-fuel moisture tables could be developed which would use the existing weather data, many of our problems would be eliminated.

TABLES

A formula developed by J. J. Keetch and George Byram,[3/] which indicates the relationship of dry bulb temperature and dewpoint temperature to fine-fuel moisture, was the basis for the tables. The formula is as follows:

$$\text{Log}_e M = 3.849244 - 0.032019DB + 0.018703DP - 0.173610\text{Log}_e(DB-DP)$$

where M=fine-fuel moisture (in percent)
DB=dry bulb temperature (degrees F.)
DP=dewpoint temperature (degrees F.)

3/ U.S.D.A. Forest Service. Derivation of spread phase tables, National Fire-Danger Rating System, Division of Fire Control, Washington, D.C. 1966.

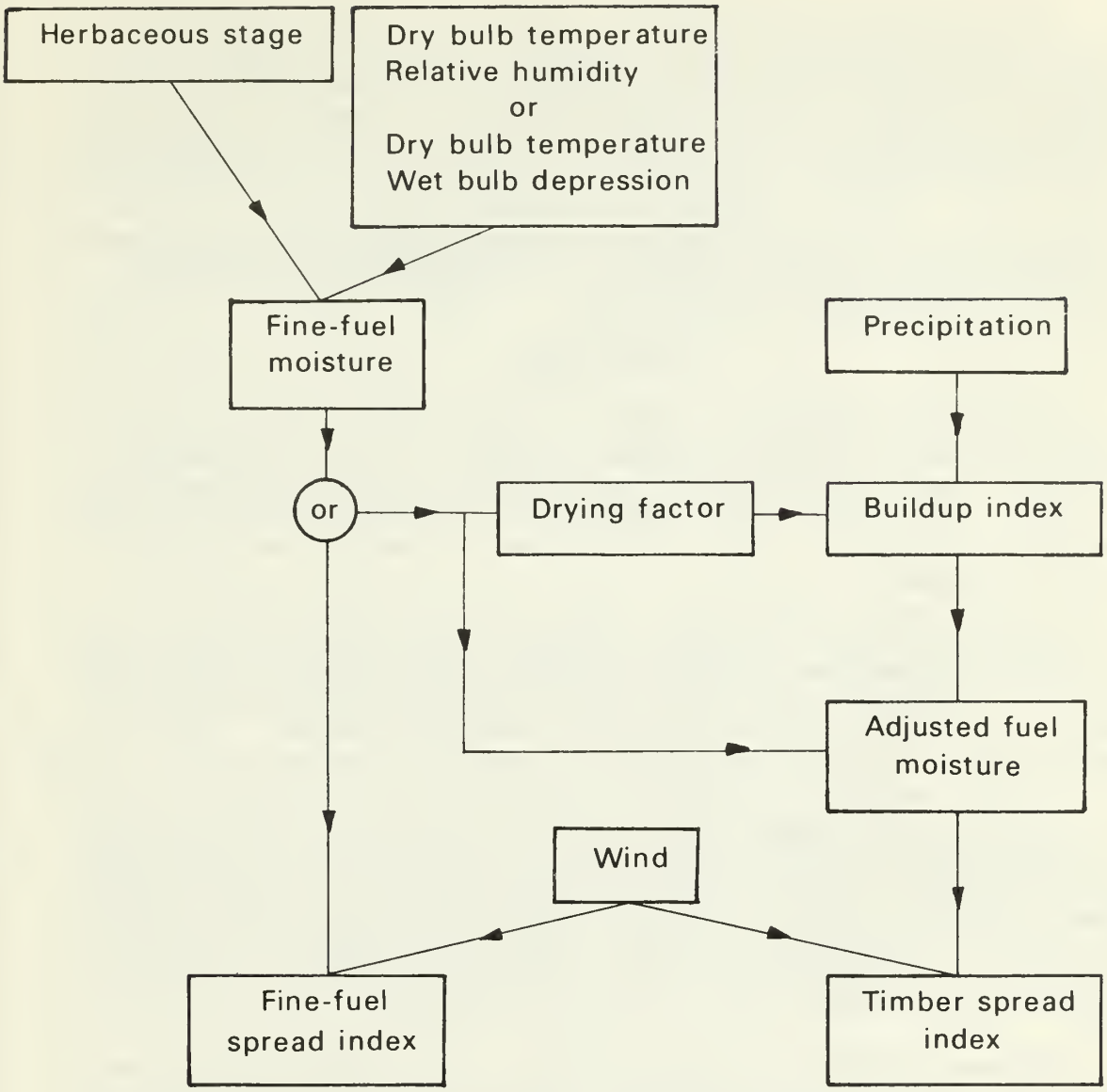

Figure 1.--*Components of the spread phase, National Fire-Danger Rating System.*

Several tables were developed, in which dry bulb temperature and dewpoint temperature were used as the entry data.[4/] The final table decided upon in the developmental phase had convenient temperature ranges to work with. Values in the table are the result of the above formula and midpoint value of the appropriate dry bulb and dewpoint temperature range (e.g., 80-84 would be represented by a midpoint value of 82, etc.). For the purpose of development and analysis, only the table for the cured herbaceous stage was considered (table 4, "Appendix"). Tables for three stages of vegetative maturation--green, transition, and cured--are given in the appendix.

COMPARISONS

The NFDRS tables used in Alaska are the version using dry bulb temperature and wet bulb depression (footnote 2). These tables and the resulting fuel moistures and danger indexes were considered as the standard. Fuel moistures and danger indexes were calculated by use of the new fuel moisture tables, but the same weather data were compared with the standard.

Fine-fuel moistures, spread indexes, and buildup indexes were calculated from data from two weather stations--Fort Yukon (2 years) and Big Delta (3 years)--by use of both the standard and the new table. These data covered easy, average, and severe fire seasons. The resulting values provided 915 data points for comparison and evaluation checks.

Fuel-moisture contents.--In a check of midpoint values of the new table for each of its 300 cells, 257 cells agree within ±0.5 percent moisture content with the standard table values. The majority of the larger differences occur below a dry bulb temperature of 32°F. where the moisture contents run too high. Other differences occur above the dewpoint range of 50°-59° F. where each indicated moisture content immediately above each of the 30+ values is too low.

Although differences of fuel moisture values obtained by the new tables do occur, many of them have a tendency to become minimized or lost in subsequent index calculation steps. The reason for this is that portions of tables, using fine-fuel moisture content as one of the entry data, use it in the form of ranges. For example, in a calculation of adjusted fuel moisture values, fine-fuel moisture content values of 9.5 through 11 would result in the same answer because of the table characteristics. This same situation exists in the spread index table calculations above a fuel moisture value of 10.

[4/] Barney, Richard J. Development of fine-fuel moisture tables for the National Fire-Danger Rating System in Alaska. 1967. (Unpublished report on file at the Institute of Northern Forestry, Juneau, Alaska.)

When the table is made relatively compact and 5° temperature ranges are used, some of the sensitivity and, therefore, accuracy is lost. However, a table using single degrees of dry bulb and dewpoint temperature would be cumbersome. A compromise of table size maintained an acceptable level of accuracy. Since dry bulb temperature ranges are used in the standard tables, this procedure was continued.

Spread and buildup indexes.--As was mentioned earlier, danger-rating indexes were calculated on the basis of both the standard and the new fuel moisture tables. Values for individual days were compared by subtraction of the index based on standard tables from the index based on the new tables, resulting in plus, minus, or zero differences. Table 1 lists the differences encountered in both spread-index and buildup-index values. A negative difference indicates that the index calculated on the basis of the new tables was less or lower than the standard table version and a positive difference indicates it was greater or a higher value.

As shown in table 1, the indexes calculated on the basis of the new fine-fuel moisture tables tended to be somewhat lower than those calculated from the standard tables. However, 84 percent of both index values were within ±5 index points of the standard, and 93 percent were within ±9 index points for the 915 days compared.

A tabulation of differences by spread-index ranges (table 2) shows that the magnitude of the difference generally decreases as the spread index increases. The very high difference of minus 30 in the 0-9 spread-index range occurred at temperatures well below freezing and is of little practical importance. Many of the other relatively large variations occurred when new fine-fuel moisture content values resulted in entry of the spread index tables one or two rows above or below the point of entry of standard fine-fuel moisture content values under the same weather conditions.

A similar tabulation for buildup-index ranges (table 3) shows that the difference increases as the buildup index increases up to a point, then tapers off. Since the buildup is a cumulative index, such a situation is to be expected. Any difference encountered is normally 10 percent or less when compared to the standard version of the index values. The maximum difference was a -14 occurring in the 80-99 buildup-index range.

SUMMARY

Fine-fuel moisture tables have been constructed with 20 ranges of dry bulb temperature and 21 ranges of dewpoint temperature of 5° F. each. The ranges break at convenient points for easy use and are limited enough in size and number to allow for a relatively compact table. In the use of these tables, calculation will automatically be

Table 1.--*Distribution of spread- and buildup-index differences based on new and standard fuel moisture tables*

Difference[1/]	Spread index		Buildup index	
	Number of cases	Percent	Number of cases	Percent
-10 and greater	8	0.9	40	4.4
-9	2	.2	12	1.3
-8	7	.8	9	1.0
-7	9	1.0	8	.9
-6	7	.8	20	2.2
-5	30	3.3	31	3.4
-4	61	6.7	79	8.6
-3	73	8.0	65	7.1
-2	141	15.4	76	8.3
-1	114	12.5	109	11.9
-0	220	24.0	299	32.7
+1	37	4.0	50	5.4
+2	50	5.5	11	1.2
+3	52	5.7	14	1.5
+4	37	4.0	18	2.0
+5	15	1.6	18	2.0
+6	20	2.2	16	1.7
+7	8	.9	7	.8
+8	4	.4	7	.8
+9	5	.5	5	.5
+10 and greater	15	1.6	21	2.3
Total	915	100.0	915	100.0

[1/] A negative difference indicates that the index calculated on the basis of the new tables was less or lower than the standard table version and a positive difference indicates it was greater or a higher value.

Table 2.--*Differences in spread-index values based on new and standard fuel moisture tables, by index ranges*

Spread-index range	Maximum plus difference	Maximum minus difference	Average difference	Number of cases
0-9	6	-30	-3.0	68
10-19	16	-8	.7	227
20-29	16	-9	.2	271
30-39	13	-7	-.2	178
40-49	16	-7	-.8	86
50-59	9	-8	-1.4	49
60-69	2	-7	-2.5	25
70-79	3	-7	-1.5	8
80-89	3	-10	-3.5	2
90-99	--	-6	-6.0	1

Note: Difference equals index value calculated with new fuel moisture tables minus index value calculated with standard fuel moisture tables.

adjusted for elevational differences since dewpoint temperatures are determined in such a manner as to account for differences in pressure or elevation.

Although differences have resulted in indexes based on the standard fine-fuel moisture table and new fine-fuel moisture table version of calculations, they appear to be well within acceptable limits for use in Alaska. We have more variation in the country and weather between our widely scattered fire-danger stations than occurs in the tables and resultant indexes. Also, we are unable, at this time, to provide any precise interpretation of the relative index numbers in terms of real values in the field. Therefore, such differences are not very meaningful at present. Differences encountered in our comparisons cannot be attributed to elevation since both the stations used are, for all practical purposes, at the same distance above sea level.

In an analysis of records where danger-rating data have been calculated from the new as well as the old tables and the two types of data are pooled, some precautions should be taken. If the primary interest is in relative differences and relationships, then no further adjustments need to be made. The data can be used as found. However,

Table 3.--*Difference in buildup-index values based on new and standard fuel moisture tables, by index ranges*

Buildup index range	Maximum plus difference	Maximum minus difference	Average difference	Number of cases
0-19	9	-6	0.1	370
20-39	13	-5	.6	222
40-59	8	-8	-2.6	101
60-79	1	-11	-2.7	83
80-99	3	-14	-5.6	42
100-119	1	-12	-7.4	40
120-139	1	-12	-3.5	15
140-159	2	-1	-.3	12
160-179	--	-3	-2.0	8
180-199	--	-4	-3.6	7
200-219	--	-5	-4.0	13
220+	--	-3	-2.5	2

Note: Difference equals index value calculated with new fuel moisture tables minus index value calculated with standard fuel moisture.

if there is a concern regarding specific index values, then perhaps all index values should be calculated on a common basis to insure a more precise analysis result. On the other hand, natural variation within an area being represented by such data may well eliminate the need for a common calculation basis for any analysis. The eventual application of results will dictate whether data are pooled when index values are a result of mixed new table and standard table calculations or whether they are placed on a common basis using one table or the other.

Tables of moisture content of fine fuels have been provided in the appendix. Versions have been prepared for the cured, transition, and green vegetative stages of fuel. Although all comparisons were based on cured vegetation tables, deviations in the less flammable stages of plant maturation should not be as critical. Even though these tables were constructed for use in Alaska, they could easily be used anywhere the NFDRS is employed. The user must, however, be aware of and able to accept the variations noted in our comparisons.

APPENDIX

Table 4.--*Fine-fuel moisture content--cured herbaceous stage*

(In percent)

Dry bulb temperature (degrees F.)	Dewpoint temperature (degrees F.)																			
	-15 to -11	-10 to -6	-5 to -1	0 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 to 44	45 to 49	50 to 54	55 to 59	60 to 64	65 to 69	70 to 74	75 to 79	80 to 84	85 to 89
105 - 109	1	1	1	1	1	1	1	1	1	1.5	1.5	1.5	2	2	2	2.5	3	3	3.5	4	4.5
100 - 104	1	1	1	1	1	1	1	1	1.5	1.5	1.5	2	2	2.5	2.5	3	3.5	4	4.5	5	5.5
95 - 99	1	1	1	1	1	1	1.5	1.5	1.5	2	2	2.5	2.5	3	3	3.5	4	4.5	5	6	7
90 - 94	1	1	1	1	1.5	1.5	1.5	1.5	2	2	2.5	2.5	3	3.5	4	4.5	5	5.5	6.5	7.5	9.5
85 - 89	1	1	1	1.5	1.5	1.5	2	2	2.5	2.5	3	3	3.5	4	4.5	5	6	7	8	10	30+
80 - 84	1	1.5	1.5	1.5	2	2	2	2.5	3	3	3.5	4	4.5	5	5.5	6.5	7.5	8.5	10	30+	
75 - 79	1.5	1.5	1.5	2	2	2.5	2.5	3	3.5	3.5	4	4.5	5.5	6	7	8	9.5	11	30+		
70 - 74	1.5	2	2	2.5	2.5	3	3	3.5	4	4.5	5	5.5	6.5	7.5	8.5	10	12	30+			
65 - 69	2	2	2.5	2.5	3	3.5	4	4	5	5.5	6	7	8	9	10	13	30+				
60 - 64	2.5	2.5	3	3	3.5	4	4.5	5	5.5	6.5	7.5	8.5	9.5	11	14	30+					
55 - 59	3	3	3.5	4	4.5	5	5.5	6	7	8	9	10	12	15	30+						
50 - 54	3.5	3.5	4	4.5	5	6	6.5	7.5	8.5	9.5	11	13	16	30+							
45 - 49	4	4.5	5	5.5	6	7	8	9	10	11	13	17	30+								
40 - 44	4.5	5.5	6	6.5	7.5	8.5	9.5	10	12	14	18	30+									
35 - 39	5.5	6.5	7	8	9	10	11	13	15	19	30+										
30 - 34	7	7.5	8.5	9.5	10	12	14	17	21	30+											
25 - 29	8	9	10	11	13	15	18	22	30+												
20 - 24	10	11	12	14	16	19	24	30+													
15 - 19	11	13	15	17	20	27	30+														
10 - 14	14	16	18	22	27	30+															

Fine-fuel moisture content (percent)	Drying factor
16.0 or more	0
10.0 - 15.9	1
7.0 - 9.9	2
5.0 - 6.9	3
4.0 - 4.9	4
3.0 - 3.9	5
2.9 or less	7

Table 5.--*Fine-fuel moisture content--transition herbaceous stage*

(In percent)

Dry bulb temperature (degrees F.)	Dewpoint temperature (degrees F.)																			
	-15 to -11	-10 to -6	-5 to -1	0 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 to 44	45 to 49	50 to 54	55 to 59	60 to 64	65 to 69	70 to 74	75 to 79	80 to 84	85 to 89
105 - 109	6	6	6	6	6	6	6	6	6	6.5	6.5	6.5	7	7	7	7.5	8	8	8.5	9	9.5
100 - 104	6	6	6	6	6	6	6	6	6.5	6.5	6.5	7	7	7.5	7.5	8	8.5	9	9.5	10	11
95 - 99	6	6	6	6	6	6	6.5	6.5	6.5	7	7	7.5	7.5	8	8	8.5	9	9.5	10	11	12
90 - 94	6	6	6	6	6.5	6.5	6.5	6.5	7	7	7.5	7.5	8	8.5	9	9.5	10	11	12	13	15
85 - 89	6	6	6	6.5	6.5	6.5	7	7	7.5	7.5	8	8	8.5	9	9.5	10	11	12	13	15	30+
80 - 84	6	6.5	6.5	6.5	7	7	7	7.5	8	8	8.5	9	9.5	10	11	12	13	14	15	30+	
75 - 79	6.5	6.5	6.5	7	7	7.5	7.5	8	8.5	8.5	9	9.5	11	11	12	13	15	16	30+		
70 - 74	6.5	7	7	7.5	7.5	8	8	8.5	9	9.5	10	11	12	13	14	15	17	30+			
65 - 69	7	7	7.5	7.5	8	8.5	9	9	10	11	11	12	13	14	15	18	30+				
60 - 64	7.5	7.5	8	8	8.5	9	9.5	10	11	12	13	14	15	16	19	30+					
55 - 59	8	8	8.5	9	9.5	10	11	11	12	13	14	15	17	20	30+						
50 - 54	8.5	8.5	9	9.5	10	11	12	13	14	15	16	18	21	30+							
45 - 49	9	9.5	10	11	11	12	13	14	15	16	18	22	30+								
40 - 44	9.5	11	11	12	13	14	15	15	17	19	23	30+									
35 - 39	11	12	12	13	14	15	16	18	20	24	30+										
30 - 34	12	13	14	15	15	17	19	22	26	30+											
25 - 29	13	14	15	16	18	20	23	27	30+												
20 - 24	15	16	17	19	21	24	29	30+													
15 - 19	16	18	20	22	25	30	30+														
10 - 14	19	21	23	27	30+	30+															

Fine-fuel moisture content (percent)	Drying factor
21.0 or more	0
15.0 - 20.9	1
12.0 - 14.9	2
10.0 - 11.9	3
9.0 - 9.9	4
8.0 - 8.9	5
7.9 or less	7

Table 6.--*Fine-fuel moisture content--green herbaceous stage*

(In percent)

Dry bulb temperature (degrees F.)	Dewpoint temperature (degrees F.)																			
	-15 to -11	-10 to -6	-5 to -1	0 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 to 44	45 to 49	50 to 54	55 to 59	60 to 64	65 to 69	70 to 74	75 to 79	80 to 84	85 to 89
105 - 109	11	11	11	11	11	11	11	11	11	12	12	12	12	12	12	13	13	13	14	14	15
100 - 104	11	11	11	11	11	11	11	11	12	12	12	12	12	13	13	13	14	14	15	15	16
95 - 99	11	11	11	11	11	11	12	12	12	12	12	13	13	13	13	14	14	15	15	16	17
90 - 94	11	11	11	11	12	12	12	12	12	12	13	13	13	14	14	15	15	16	17	18	20
85 - 89	11	11	11	12	12	12	12	12	13	13	13	13	14	14	15	15	16	17	18	20	30+
80 - 84	11	12	12	12	12	12	12	13	13	13	14	14	15	15	16	17	18	19	20	30+	
75 - 79	12	12	12	12	12	13	13	13	14	14	14	15	16	16	17	18	20	21	30+		
70 - 74	12	12	12	13	13	13	13	14	14	15	15	16	17	18	19	20	22	30+			
65 - 69	12	12	13	13	13	14	14	14	15	16	16	17	18	19	20	23	30+				
60 - 64	13	13	13	13	14	14	15	15	16	17	18	19	20	21	24	30+					
55 - 59	13	13	14	14	15	15	16	16	17	18	19	20	22	25	30+						
50 - 54	14	14	14	15	15	16	17	18	19	20	21	23	26	30+							
45 - 49	14	15	15	16	16	17	18	19	20	21	23	27	30+								
40 - 44	15	16	16	17	18	19	20	20	22	24	28	30+									
35 - 39	16	17	17	18	19	20	21	23	25	29	30+										
30 - 34	17	18	19	20	20	22	24	27	30+	30+											
25 - 29	18	19	20	21	23	25	28	30+	30+												
20 - 24	20	21	22	24	26	29	30+	30+													
15 - 19	21	23	25	27	30	30+	30+														
10 - 14	24	26	28	30+	30+	30+															

Fine-fuel moisture content (percent)	Drying factor
26.0 or more	0
20.0 - 25.9	1
17.0 - 19.9	2
15.0 - 16.9	3
14.0 - 14.9	4
13.0 - 13.9	5
12.9 or less	7